AIM-BA: Portable AI-Assisted Capillary-Blood Analyzer

TEAM M081

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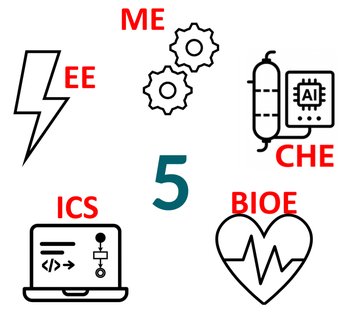


Objective

To design, construct, and validate a low-cost, portable point-of-care (POC) blood analyzer that delivers rapid, clinical-grade diagnostics in resource-limited settings.

Problem Statement

Traditional diagnostic methods rely on toxic Potassium Cyanide reagents, require continuous cold-chain refrigeration, and demand manual sample pipetting. These issues increase operating costs, limit deployment in remote areas, and introduce significant biohazard risks to the operator.

Constraints & Specifications

Project Constraints

Accuracy: Total error <10% (compensates for lipemia/hematocrit).

Privacy: 100% offline edge-AI processing.

Risk Mitigation: Zero blood leakage during operation.

Low Cost: Budget ~1,575 SAR; 3-parametric capable to slash consumer costs.

Technical Specifications

Speed: Total Capture-to-result in ≤ 10s.

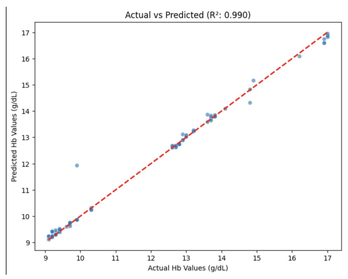
Volume: Process micro-volumes ≤ 20 µL.

Stability: 12-month shelf life (25° C, ≤60% RH).

Concep Design

Model Accuracy

Achieved a **predictive accuracy of $R^2 = 0.99$** with a minimal MAE of 0.0999.

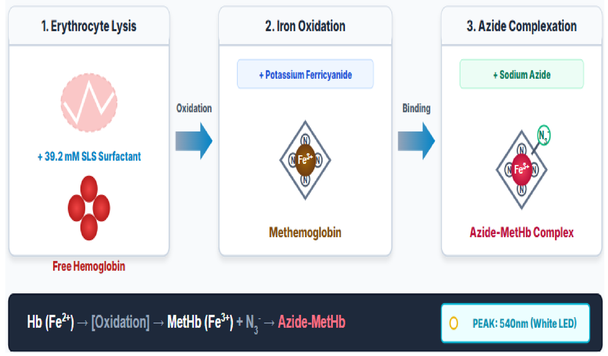


Validation & Results

Discipline / Targets	Engineering Proof	Status
CHE	SLS clears lipemic turbidity. Trehalose matrix stabilizes reagents. Kinetics hit flat plateau at t=30s.	✓ Met
BIOE	Validated 8–18 g/dL calibration ensures clinical-grade diagnostic accuracy across the physiological range.	✓ Met
ME	3D darkroom is <150mm and 100% light-isolated. PMMA channel exhibits void-free, 996 Pa capillary fill.	✓ Met
EE	Integrated 12.3MP CMOS and calibrated 540nm LED. Operates >1hr natively on 5V/3A low-voltage battery.	✓ Met
ICS	Offline edge-AI regression pipeline executes in less than 10s. Achieves <10% MAE	✓ Met
Integrated	Total test time ~35s. Processes exact 6.24 µL volume with 100% bio-seal containment (zero leakage).	✓ Met

Chemical Reaction Mechanism

- Figure 3: Azide-Methemoglobin Conversion Pathway



Conclusions

✓ Proven Concept: Delivered a highly accurate, cold-chain-free diagnostic tool.

✓ Enhanced Safety: Solid-state reagents and Edge-AI eliminate toxic chemicals and biohazard risks.

✓ Future Scalability: Architecture is primed for 3-parametric multiplexed measurements, drastically reducing point-of-care costs for end-consumers.